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The Energy Problem -- Crude Oil

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ABSTRACT

This paper discusses the national energy problem as it affects the demand for and availability of crude oil. Forecasts of energy demands to 1990 have been made based on population trends and changing life styles in the USA. Projections of energy supplies show a rapidly increasing gap between supply of crude oil and demand for crude oil from the early 1970's through 1990. The need for imported crude oil to supply the forecast deficit is discussed. The political and economic implications of these imports are also discussed. The need for refineries, port facilities, tankers, and pipelines are presented. Finally, recommendations are made for actions to be taken to meet our energy needs.

I. INTRODUCTION

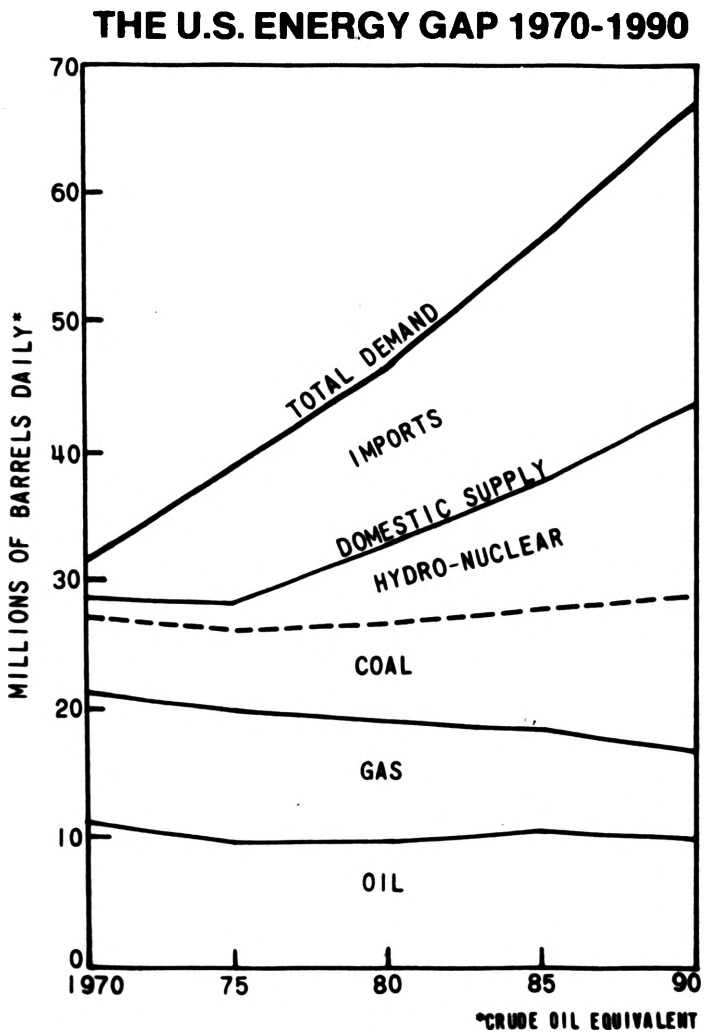
Many Americans first became conscious of a gasoline supply problem during the summer of 1973. For the first time, spot shortages of gasoline appeared in a number of areas, and motorists found they were unable to buy all the gasoline they would have liked. In the fall of 1973, when the Middle East oil exporting countries imposed an embargo on crude oil to be shipped to the United States, shortages of gasoline, home heating oil, aviation turbine fuel, and other products of the petroleum refinery threatened to become acute. The government responded to the crisis with alacrity and established allocation systems so we could all share the shortage. Motorists have become frustrated and angry at having to wait in line for gasoline and at finding they could not buy all the gasoline they wanted.

Despite these shortages, however, total energy consumption in the USA in 1973 actually increased 4.8 percent over 1972. Consumption of fuel in the transportation sector increased 3.8 percent relative to 1972. Thus, even though the energy industry supplied more fuel in 1973, demand was increasing faster than industry's ability to supply. Let us examine the national energy situation in order to understand how the shortages came about and to project the future of crude oil and refined product supplies.

The U.S. energy gap from 1970 projected to 1990 is shown in Chart 1. It will be seen that total energy demand is predicted to increase steadily throughout the period while domestic supply remains relatively constant through 1975 and then increases modestly. The difference between demand and supply is projected to be made up of imports of crude oil and refined products. The large amount of imports may create intolerable strains on our balance of payments account with the rest of the world. The political and economic implications of the large dependence on crude oil imports have become painfully apparent to us during the recent Mid-East embargo.

Our examination of the energy supply and demand picture shows that only oil can supply the major part of the growth in the nation's energy needs for the next decade at least. At best, newly found domestic oil can just offset declines in older fields and therefore the additional oil needed will have to come from abroad. Some contribution towards supplying the energy requirement will come from nuclear sources towards the end of the 1970's, and this contribution will later accelerate.

CHART I



II. THE ENERGY OUTLOOK FOR THE USA

Premises of the Forecast

The forecast on which this paper is based necessarily depends on various premises. The assumptions are as follows:

1. Population

There will be population growth at the rate of 1 percent per year. The most probable projection is based on the Census Bureau's Series E projections which give by 1990 an increase of 46 million people over the 1970 population of 205 million.

The post-World War II "baby boom" generation is now the 15-25-year age group. Between 1970 and 1990 they will increase the labor force from 86 to 115 million and the number of households from 63 to 90 million.

2. Economic Growth

There will be annual growth in real Gross National Product of 5.7 percent through 1975. The rate will then decline to 4.3 percent and after 1980 to 3.8 percent.

3. Oil Imports

The Oil Import Program will be revised so as to allow imports to satisfy the difference between domestic oil demand and production.

4. Natural Gas Regulation

It is assumed that regulatory control will be modified, with some increase allowed in wellhead prices to stimulate development of new supplies and to reflect the value of gas compared to alternative fuels.

5. Land Use Regulation

By 1975 the Federal government will develop new guidelines on land use within which states will develop their own plans. These will cater to the siting of energy facilities such as power plants and refineries.

6. Pollution Standards

Severe restrictions proposed for auto emissions will be adhered to and the control of sulfur emissions extended.

7. Technological Developments

The forecast takes into account foreseeable innovations. These include development of commercial stack gas scrubbing by 1977 and electric battery/fuel cell cars by 1985.

8. Transportation

Individual cars will remain the primary mode of transporting people but there will be a trend to smaller cars as costs escalate. The various forms of mass transit are estimated to have no major effect on motor gasoline consumption in the forecast period.

Aviation load factors will be about 55 percent from 1975 to 1990.

9. Residential

The average size of homes will decrease. More efficient home insulation will moderate space heating demand. The residential market will get preferential allocation of existing gas supply.

10. Energy Supply

Crude Oil

Estimates are based on two offshore lease sales totaling 1 million acres per year. North Slope crude from Alaska is premised to reach West Coast refineries in 1976 (This is now known to be optimistic). Full Alaska pipeline capacity will be reached by 1982. Oil will be available overseas to supply required imports.

Natural Gas

There will be a Mackenzie Valley gas line from the Canadian Arctic by 1978, to which Alaska North Slope gas will be tied in by 1980. Volumes of overseas liquefied natural gas (LNG) will be limited due to high costs and uncertainty of sources.

Nuclear

Nuclear development through 1985 is constrained by long lead times of 7-10 years. Thereafter, it will accelerate.

Coal

Long-term growth is envisaged. Environmental restrictions on strip mining will affect rate of short-term growth.

Unconventional Raw Materials

A major effort to develop coal gasification is expected. Shale oil and conversion of coal to liquid hydrocarbons are not projected as significant supply sources before 1990 principally because of technological problems, but also because high manufacturing costs will require a high market price for these synthetic energy raw materials. No other new sources of energy will become substantial suppliers before 1990.

U.S. Energy Demand

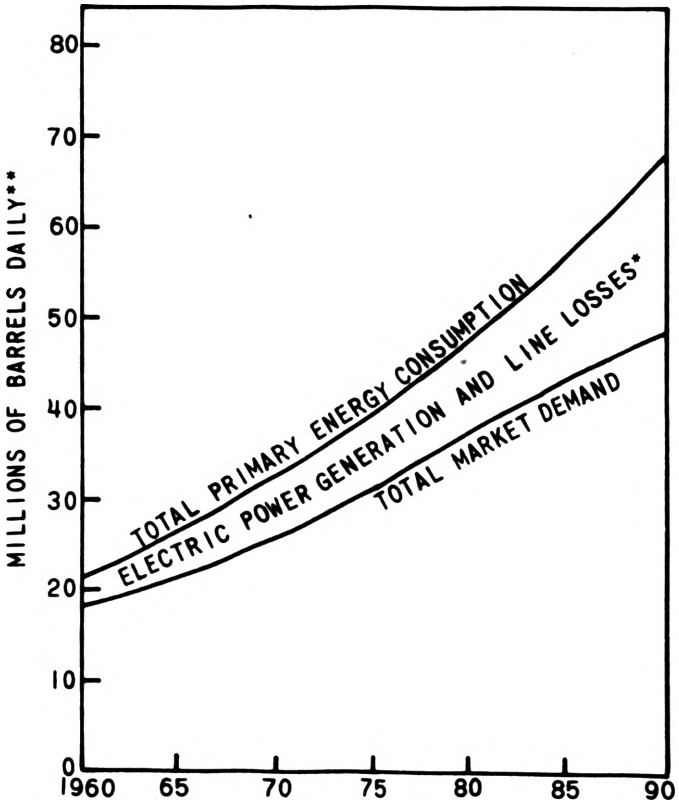
The United States - with one-sixteenth of the world's population - consumes one-third of the world's energy. We use more energy to heat and cool homes; we travel more miles and produce more goods than any other nation. Energy cooks our food, lights our way, and runs our machines.

Energy consumption more than doubled in the last 20 years. As shown in Chart 2, consumption will double again between 1970 and 1990, increasing from the equivalent of 31.8 million barrels of crude oil daily to 67 million barrels. The annual average growth rate, however, is predicted to be lower at about 3.8 percent.

The nation's energy is primarily used by five major markets: transportation, industrial, residential, commercial, and electricity generation. Of these markets, electricity generation, transportation, commercial, and (within industry) chemical, grow faster than total energy demand. Other markets grow more slowly. A particular feature of the U.S. energy consumption pattern has been the sharp rise (8.2 percent 1971/72) in the demand for distillate oils. This has been caused by various factors. Shortages of natural gas have led to switches to oil. Then there have been the effects of environmental and sulfur restrictions on the use of coal and residual fuel oil for electricity generation. This combination of circumstances has caused domestic distillate to be used increasingly for boiler heating.

CHART 2

U.S. DOMESTIC ENERGY DEMAND



*ALSO INCLUDES LOSSES FROM GASIFICATION AND LIQUEFACTION.

**CRUDE OIL EQUIVALENT

The Transportation Market

The overall growth of the transportation market can be seen in Chart 3. What is not clear from the chart is the important role motor gasoline plays in the total transportation picture. The annual miles driven by the average driver have been increasing linearly for the last 20 years. The prospect is that this will continue to be a highly mobile society, and therefore transportation will continue to be a major energy consumer.

Fuel consumption per mile is expected to increase significantly. Emission control and safety devices fitted to new automobiles will decrease average miles per gallon by about 15 percent during the late 1970's.

Battery and fuel cell cars are estimated to have no major impact before 1990. There may be 2 million such cars by 1985 and 6 million by 1990, but this will be less than 5 percent of the total car fleet.

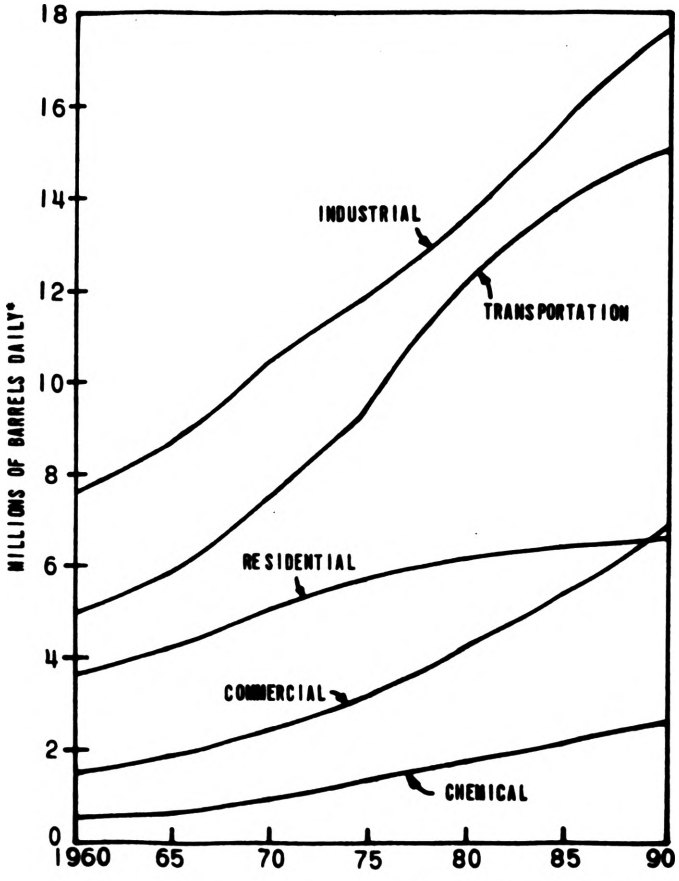
Aviation kerosene-type jet fuel has been a rapidly growing portion of the transportation market. Future growth rate is expected to decrease as market saturation occurs and as larger, more efficient aircraft continue to displace the present fleet. Seating capacities of aircraft have risen steadily over the years and this trend should continue if only by replacement of older, smaller aircraft. Fuel consumption per seat mile of newer planes, which use more efficient engines, is much lower than for previous models.

The Industrial Market

Chemical and allied products apart, industry will show only a modest growth in energy consumption. The level of industry consumption will also be moderated by industry's improved efficiency in energy use, and this trend is likely to be further stimulated by

CHART 3

INDIVIDUAL MARKET DEMANDS



*CRUDE OIL EQUIVALENT

rising energy costs. Dupont and Alcoa, for example, have already developed plans for achieving significant fuel economies. Shell Oil has committed itself to achieving a 10-percent reduction in energy use in refineries over a period of 2 to 4 years.

Petrochemical feedstock demand will grow very rapidly at an average annual rate of more than 5 percent.

The Residential and Commercial Market

Several factors - particularly population and disposable income - influence the demand for energy of the residential market. It is estimated that this demand will increase from the equivalent of 5 million barrels in 1970 to 6.7 million barrels daily in 1990. Growth in this market is likely to be slower than in the past as the result of better heat insulation in new houses, coupled with the trend toward smaller, mobile, and multiple family dwellings which have reduced requirements for space heating and cooling.

The commercial market includes stores, office buildings, schools, hospitals, and government buildings. Consumption of energy is directly affected by the level of business activity and the demand for public services. It is estimated to increase at more than 5 percent annually and in volume to amount to about 7 million barrels daily by 1990. In both the residential and the commercial markets, gas will be the main supply source throughout the period but electricity will play a growing role.

The Electric Utilities Market

Electricity is a convenient form of energy for customers. It is normally available continuously and automatically, and the precise amount needed is instantly delivered so that the user needs no inventory. Discounting conversion and line losses, it is efficient and it causes the consumer no pollution problems. For these reasons, industry has turned increasingly to electricity with a resulting growth rate annually during the last decade of nearly 8 percent. Looking ahead, between 1970 and 1990, an annual growth rate of 6.4 percent is forecast. The industrial market (including oil and gas companies) is the largest purchaser requiring 41 percent in 1970 and 42 percent in 1990. The residential market which today accounts for almost a third of electricity sales is estimated to fall to 22 percent by 1990 mainly because of energy conservation measures. The commercial market is rapidly increasing its electricity use with the spread of air-conditioned shopping centers, schools, and office buildings, and it is expected to account for 34 percent of total demand by 1990.

Fuel Requirements of Electric Utilities

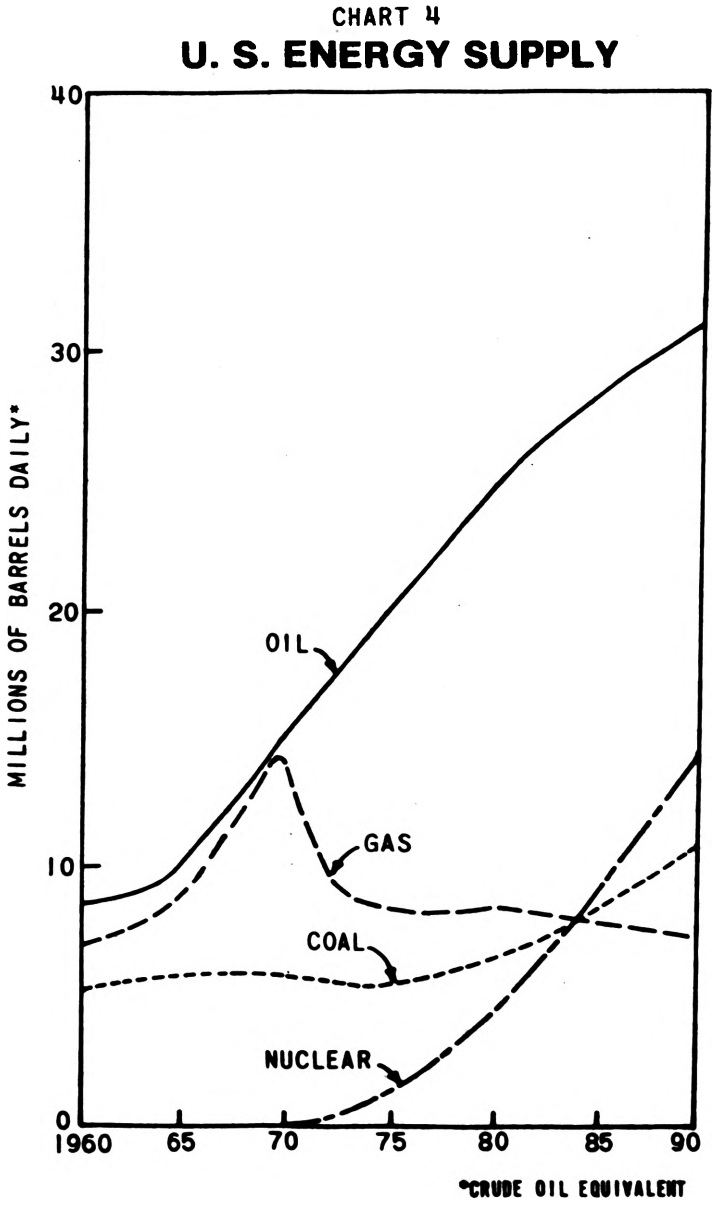
Energy requirements during the period to 1990 will be met from various sources: nuclear, coal, natural gas, oil, and hydroelectric power.

The use of natural gas is forecast to decline because of supply shortage, and hydroelectric power will show only modest growth because of lack of suitable sites. Short-term, oil will replace gas in the fuel supply, and coal will increase its role after stack gas scrubbing is developed fully by 1980. But in the long term, nuclear power will be the fastest growing source of fuel for utilities and will be 58 percent of total supply by 1990.

U.S. Energy Supply

How the United States is expected to meet its energy demand is shown in Chart 4. As the graph shows, oil will be the immediate mainstay of our energy diet, and during the '70's, its contribution to total energy requirements will increase from 44 percent in 1970 to 50 percent by 1980. This increase reflects the projected decline in natural gas supplies and the fact that alternative energy sources will all take a long time to develop. However, domestic reserves of oil and gas are diminishing, and it now appears inevitable that the United States - which now depends on foreign sources for over 25 percent of its petroleum needs - will become considerably more reliant on imports. During the 1970's, for example, most of the growth of the nation's energy requirements (16 million barrels per day) will have to be supplied by imports of foreign oil. By 1990, it is projected that imports will account for about two-thirds of the country's oil needs.

CHART 4



Oil

Steadily increasing demand, coupled with reduced natural gas supplies, coal's environmental drawbacks, and the delays in nuclear power, have created an energy gap which can only be filled by oil. Demand on supplies is currently about 16 million barrels per day. This is expected to increase by 1990 to nearly 33 million barrels per day.

Domestic production, as shown in Chart 5, will not be able to meet this demand. It is now considered that U.S. crude oil production has peaked at just over 9 million barrels per day and will now decline, even though Arctic crude and production from discoveries in the Lower 48 slow this trend. Production from the Arctic is expected to average about half a million barrels daily in 1977 and is forecast to peak during the late 1980's at 3 million barrels per day. Development of Prudhoe Bay in Alaska along with other discoveries in the Arctic and Lower 48 should help to hold U.S. crude production around the 9 million barrels per day mark during the 1980's.

The dotted lines on Chart 5 indicate the extent to which production would fall were there no additional oil discoveries. There certainly will be new discoveries and the lines show that by 1990, more than half the combined supply from these areas is estimated to come from sources still to be found.

During the period to 1990, oil from shale and coal will make a small contribution of say 1.5 million barrels per day to total energy supplies. An accelerated development program could increase these quantities to perhaps 3 million barrels per day by 1990, but the rate of progress is likely to be limited by pressures on the construction industries and such considerations as water availability, mining labor, and mining equipment.

As shown in Chart 5, the remainder of the U.S. oil supply must come from increasing amounts of foreign sources, including Canadian.

III. PROBLEMS ARISING FROM THE DEMAND/SUPPLY PROJECTION

Provision of Crude Oil

As previously shown, increased energy demand in the next 10 years can only be met by oil supply. To provide by 1980 10 million barrels per day over and above present consumption levels is, by any standards, an immense undertaking. Put graphically, 10 million barrels per day is equivalent to the production of more than five new Alaska Prudhoe Bay fields. To supply oil in this quantity calls not only for the discovery of new fields both at home and overseas, but also for transportation and terminal facilities for the large increase in imported supplies, a massive expansion of refinery capacity, and enormous amounts of capital.

Most of the increase in energy demand will have to be met from foreign sources. The realistic prospect is that a vigorous domestic exploration and production effort will at best only enable the current supply level to plateau instead of decline. To date, the physical problems involved in importing very large volumes of crude oil and products have been given inadequate consideration. Nor has there been much broad public appreciation of the international dimension in which oil supply questions will have to be resolved. For this reason, the import need is dealt with later in the context of the changing pattern of world supplies.

Refinery Capacity Expansion

To process the additional crude oil supplies, a vast expansion of domestic refinery capacity is called for, amounting to some 8 million barrels per day in 1970/80 period. This is equivalent to about 58 average size refineries. Because of environmental problems and capital costs, the industry is likely to make maximum use of the expansion possibilities of existing refineries. This forecast assumes timely and appropriate land use policies and environmental regulations that do not make the construction of new refineries and the expansion of existing plants impossible.

Pipeline Capacity

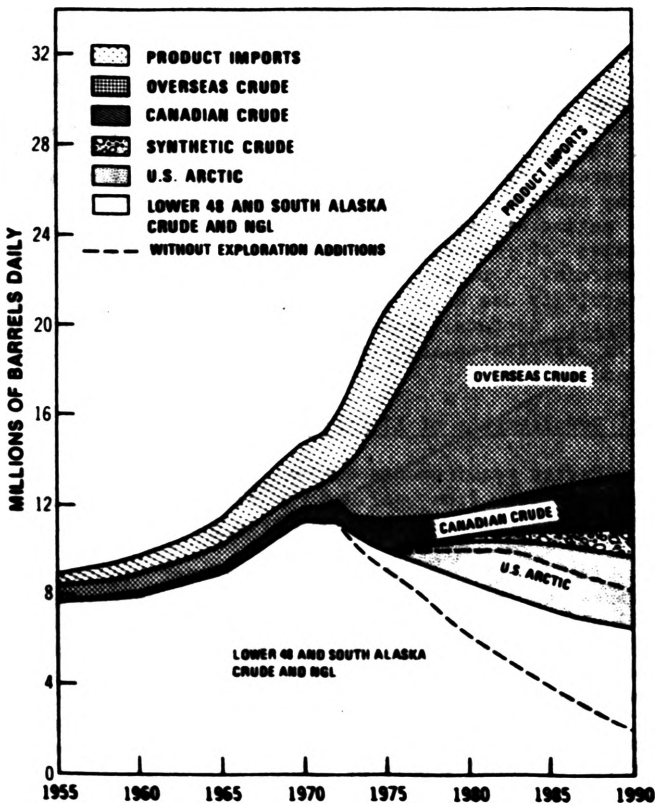
It appears that by 1980, there will be need for new pipeline capacity beyond present expansion potential both for crude oil and products. This will include product pipeline capacity from the Gulf Coast to the East Coast and crude pipeline capacity from the Gulf Coast to the Midwest.

Shipping and Port Facilities

For its crude and product imports, the U.S. will need by 1980 tanker capacity equivalent to about 325 supertankers, the class of giant transport capable of carrying 1.5 million barrels of oil. This means the arrival daily of six such supertankers, and, since these ships cannot be unloaded in a single day's time, approximately 25 receiving berths will be necessary.

CHART 5

U. S. PETROLEUM SUPPLY



If receiving berths are not available, the alternative is offloading in the Bahamas or Nova Scotia and then reloading on to smaller ships capable of entering U.S. ports. This, of course, means increased cost.

Capital Investment

Provision of these and other necessary facilities will require huge capital investment. During the 1970/1980 period, this is estimated to total over $150 billion.

Cost of U.S. Oil Imports

By 1985, the total annual cost of imported oil could rise to between $30 billion and $70 billion, as shown in Chart 6. These figures are calculated by applying the forecast volume demand against a range of published projections of future oil prices made by responsible experts. Even by 1975, and using crude oil prices that prevailed before the embargo was imposed, expansion of imports will add $8 billion to the import bill.

The seriousness of this dollar outflow is of prime significance in the determination of future U.S. energy policies.

IV. THE INTERNATIONAL DIMENSION U.S. OIL IMPORT NEEDS AND WORLD SUPPLIES

Crude Oil Imports

Our forecast is that U.S. imports of overseas crude oil will increase dramatically from 700 thousand barrels per day in 1970 to 4.3 million barrels per day in 1975. Western Hemisphere sources will be unable to expand their supplies significantly and almost all of this increase will therefore come from Eastern Hemisphere sources in the Middle East and Africa. The significance of Eastern Hemisphere supplies is shown in the following table:

PROJECTED U.S. IMPORTS
(Million Barrels Per Day)

	1970	1980	1990
Total Crude Imports	1.3	11.4	18.3
Overseas Crude Imports	0.7	10.2	16.2
Eastern Hemisphere Imports	0.3	9.2	14.2
Eastern Hemisphere as % Total	23	81	78

Product Imports

Although long term there are clear balance of payments advantages in having import regulations that favor U.S. domestic refining, in the short term there will probably have to be a rapid increase in distillate and residual imports if demand is to be met. The extremely rapid increase in these requirements between now and 1975 will strain the world's refining capability.

The vast expansion foreseen for U.S. oil imports will necessarily have profound effects on worldwide energy supply patterns in the years immediately ahead, and repercussions that are difficult to gauge over a broad range of political and economic matters.

World Energy Demand

World energy consumption is expected to nearly double between 1970 and 1980, increasing from the equivalent of 100 million barrels of crude oil per day to 170 million barrels. By the year 2000, it is projected to increase fourfold, reaching the equivalent of over 400 million barrels daily.

During 1970, the U.S. consumed about one-third of the world's energy. Its share is forecast to decline to 22 percent by 2000, because energy growth rates in Japan, USSR, East Europe, and the developing world are all projected to be higher than in the U.S. over the next 20-30 years.

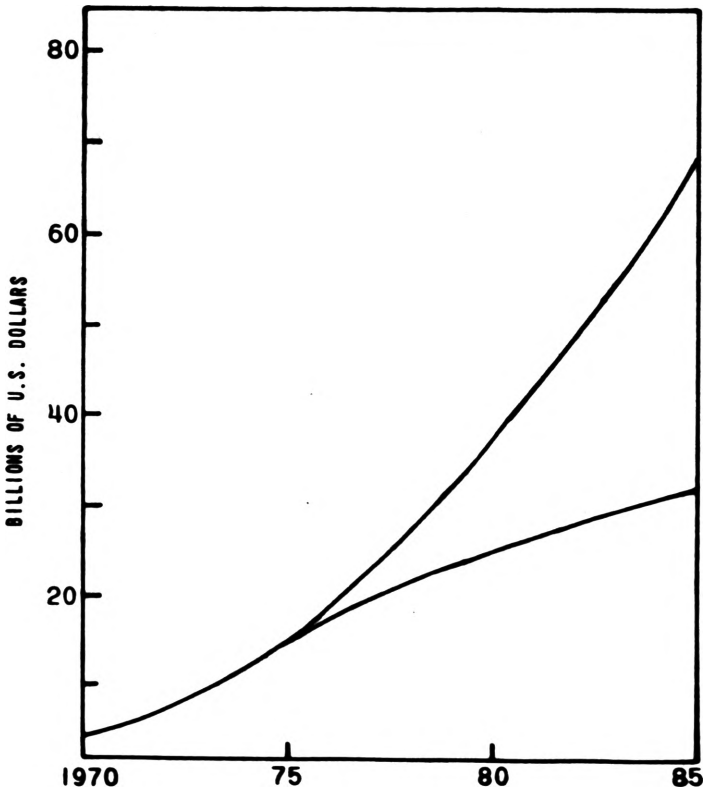
Relative growth rates are shown in the following percentage table:

	1970-1980	1980-1990	% A.A.I. 1970-1990
USA	4.1	3.4	3.8
Western Europe	4.8	5.0	4.9
Japan	7.2	7.2	7.2
Communist Areas	6.5	4.9	5.7
Others	6.8	5.5	6.1
World	5.5	4.8	5.1

Sources of Crude Oil

Chart 7 shows the world's proven reserves of crude oil as of January 1, 1971. The Middle East, with 342 billion barrels of proven reserves, has almost 9 times the reserves of the USA. It is clear that we shall be heavily dependent on the Mid-East for petroleum supplies over the near term. Worldwide oil movements in 1970 and 1980 are shown in Charts 8 and 9. Here, again, the increase in oil movements from the Mid-East is shown to be substantial if the near term demands of the oil-consuming nations are to be met.

CHART 6
RANGE OF COSTS OF U.S. OIL IMPORTS



V. POTENTIAL EFFECT OF ENERGY CONSERVATION MEASURES ON ENERGY DEMAND

In view of the increasing demands for fossil fuels detailed in this forecast and the limited sources of domestic supply, widespread interest in reducing growth in demand is developing. The Federal government has been particularly active in this area, and the so-called Kupperman Report (from the Office of Emergency Preparedness) and reports prepared for the Senate Committee on Interior and Insular Affairs (Senator Henry Jackson, Chairman) are recent results of this activity. We have evaluated potential reductions in demand which might be achieved and conclude that by 1990 a saving of about 7 million barrels per day (crude oil equivalent) is possible relative to the forecast demand. Many of these savings require changes in life style only achievable through an extraordinary national consensus.

Transportation Market

The largest potential (3 million barrels per day of gasoline) could be realized by increasing the proportion of very small cars in the total U.S. automobile fleet. By 1990, we forecast that half the automobile fleet will consist of compacts or subcompacts which will average not much more than 15 miles per gallon. A much smaller vehicle designed primarily for urban use and probably seating only two passengers would be expected to obtain 35 mpg or more. Complete substitution of this smaller vehicle for compact and subcompact automobiles would be possible by 1990 if the energy problem is accepted as being sufficiently severe. The resultant saving in motor gasoline would be 3 million barrels per day if these small vehicles were used for half the total driving.

An additional 450 thousand barrels per day of aircraft turbine fuel could be saved by increasing average load factors from the forecast level of 55 percent to 80 percent. This would undoubtedly cause serious inconvenience to air travelers since many aircraft would be filled to capacity and the interval between flights lengthened.

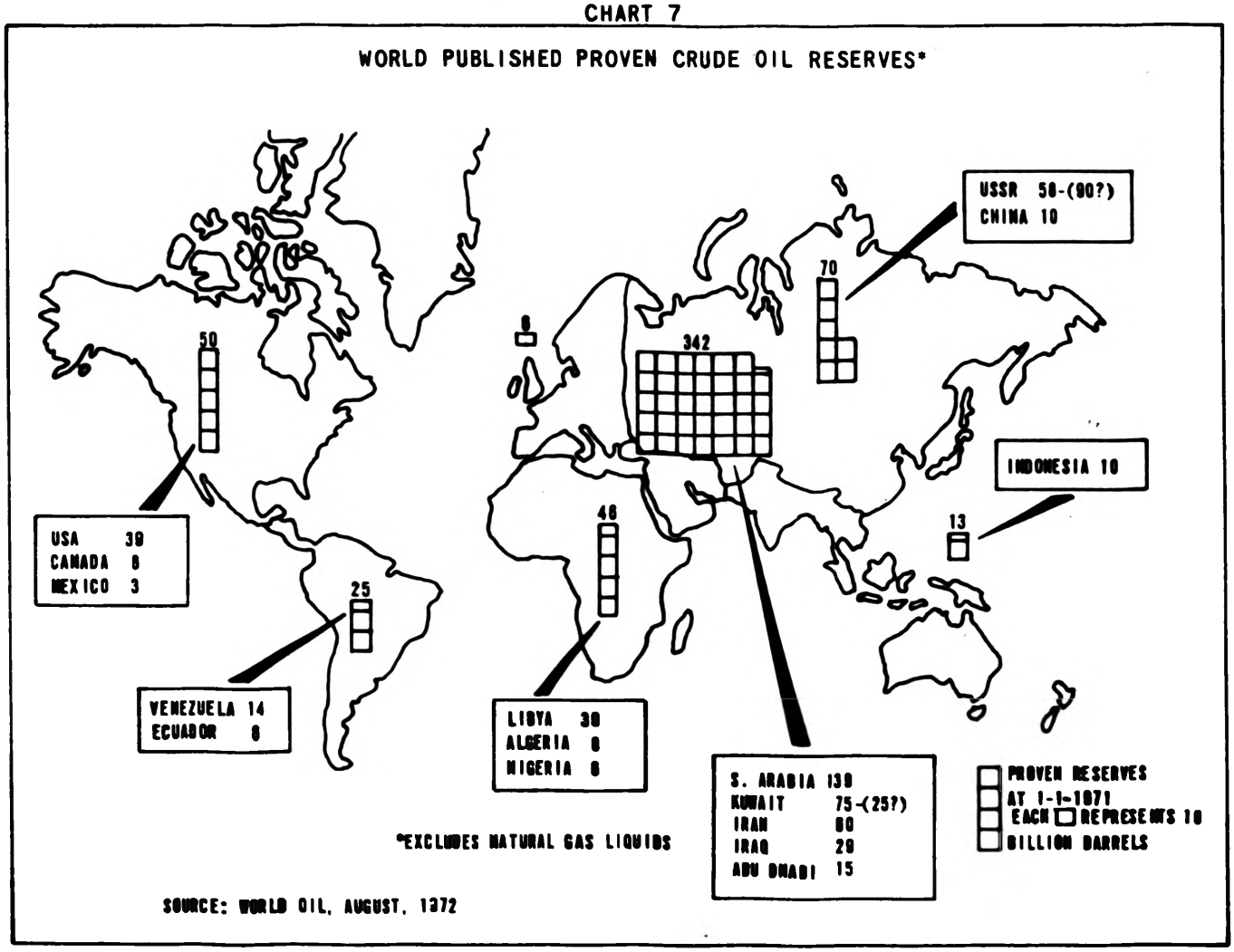
The combined motor gasoline and turbine fuel savings could be nearly 3.5 million barrels per day.

Industrial Market

The next largest potential saving could be in the industrial market. In some industries, such as iron and steel production, the reasonable expectations for increased efficiencies have been included in our base forecast. In others, new technology not now foreseen can be expected to increase efficiency beyond that forecast.

In the chemical process industries (including petroleum refining), however, increased capital expenditures can usually lead to increased heat

CHART 7



recovery and as fuel prices rise, the incentive to make the capital expenditures increases. A 5 to 10 percent decrease in energy use per unit of output can be expected from increased heat recovery. Use of more energy-efficient processes might contribute somewhat smaller savings. Total savings in the industrial market of 1.5 million barrels per day by 1990 seem possible.

Utility Market

Savings in the utility market could amount to 1 million barrels per day of fuel oil by 1990. Over 80 percent of this potential saving arises from more efficient generation, and of this about half is attributable to more widespread use of currently available high efficiency steam plant design and operation. The balance would require commercialization of new system technology such as MHD (magneto hydrodynamics - a process for more efficient direct conversion of heat energy to electricity) or organic working fluids to use low-level heat presently rejected to cooling water or the atmosphere. A smaller amount could be obtained from more efficient transmission.

Residential/Commercial

Within the residential/commercial market, the largest use of energy is for space heating and cooling. Recent (1971) FHA insulation standards will reduce this demand if widely applied, and our forecast assumes application in 70 percent of new houses. If the balance of new houses were insulated so as to comply with these standards, a saving of 150-200 thousand barrels per day would result by 1990. Application of additional insulation to the presently existing houses could save an additional 300-350 thousand barrels per day for a total potential saving in the residential market of 400-500 thousand barrels per day. Even more stringent standards have been proposed which could save a further 200-300 thousand barrels per day, but these have not been publicly accepted.

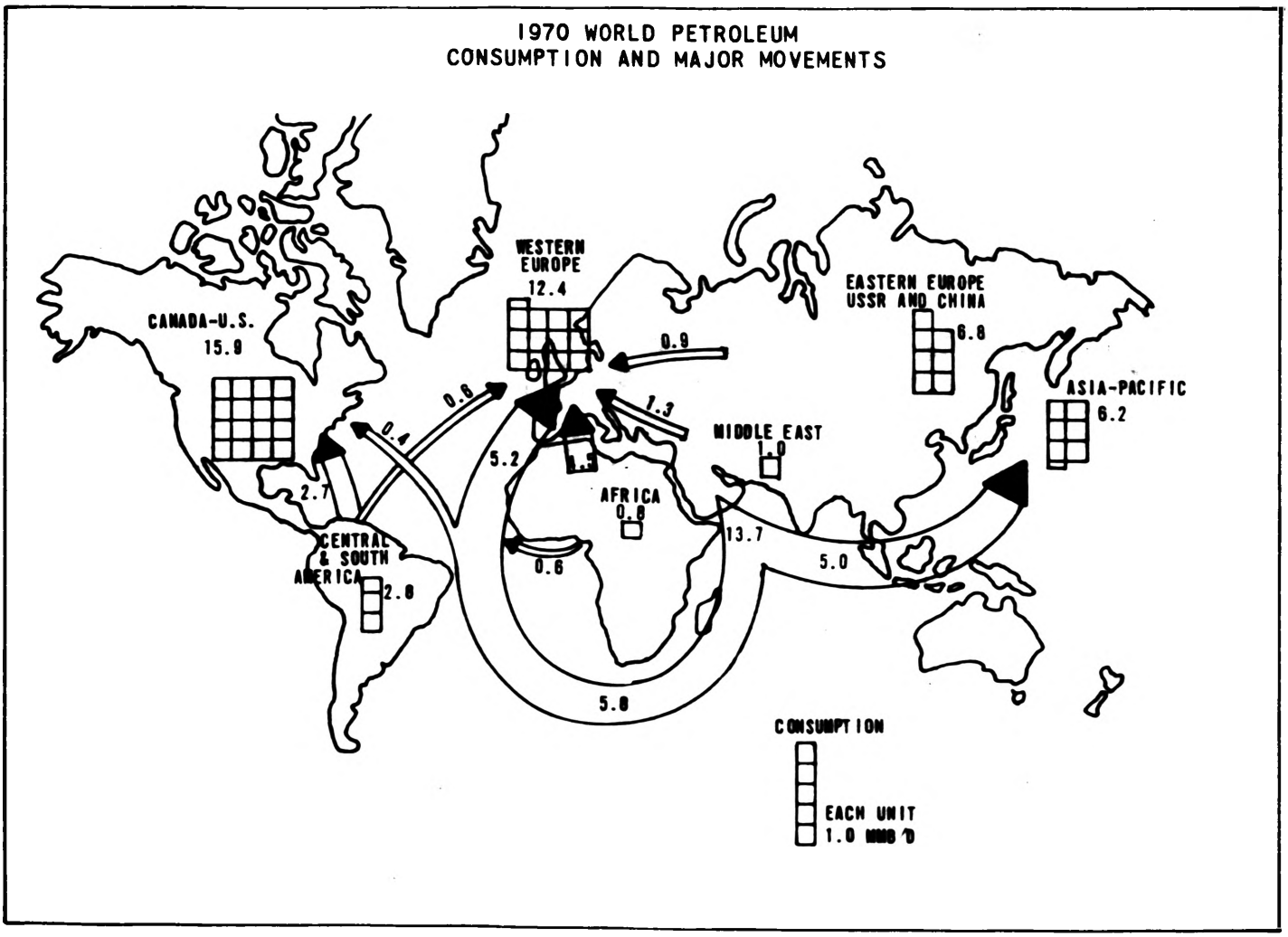
The commercial market (which includes large apartment buildings) could contribute smaller savings estimated at 200 thousand barrels per day. The overall potential saving in the residential/commercial market would be 800,000-1 million barrels per day.

Other Conservation Possibilities

Mass Transit

The development of efficient mass transit is becoming an increasing community priority. Mass transit systems, however, have long lead times and very high capital costs. Hence, the impact on transportation energy demand can, unfortunately, only

CHART 8



be a long-term possibility. The increased use of buses and of car-pooling would similarly have minor impact as only a small percentage of commuters would be affected, but they are worthwhile efforts nevertheless.

Taxation

Increased taxation on automobile horsepower, higher parking charges, and the like could have an impact, but it is considered that such measures would be less effective and acceptable than the use of smaller cars. Moreover, the switch to small cars would not require reduction in miles traveled to achieve energy savings.

Long Industry Lead Times

In considering measures to ease the energy supply situation, the importance of long lead times cannot be overemphasized. In some activities, a sufficient concentration of brains and money can solve problems through "crash" action. In the oil industry, however, as the diagram in Chart 10 shows, planners must think in terms of several years, not months. An understanding of the time factor in oil operations is fundamental.

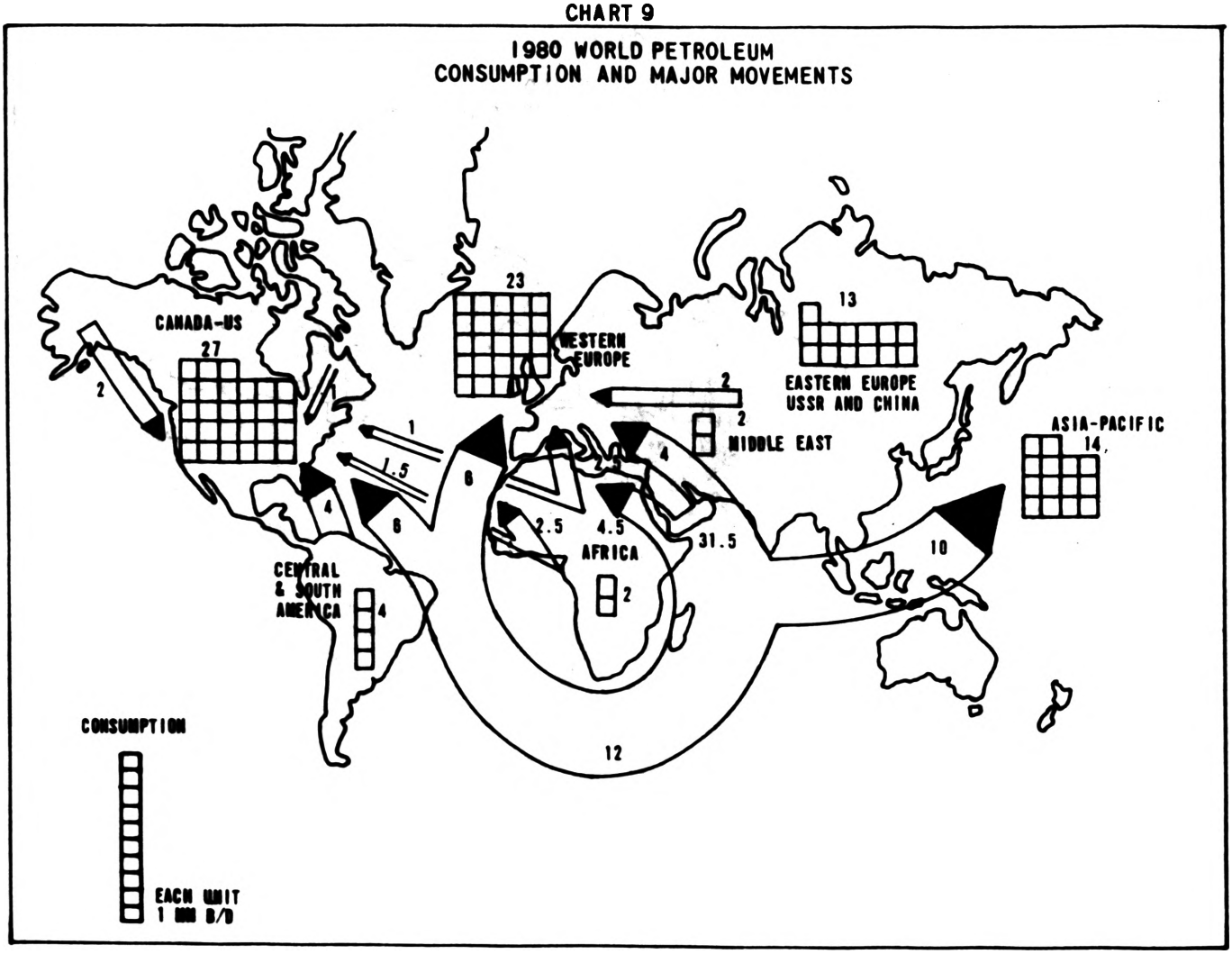
VI. GOVERNMENT MEASURES THAT COULD EASE THE ENERGY SUPPLY SITUATION AND REDUCE DEPENDENCE ON FOREIGN IMPORTS

If the demand/supply forecast outlined in this paper is even approximately correct, it seems clear that a fundamental transition is taking place in the U.S. energy supply position, with sharply increased dependence on foreign oil the key factor.

There is thus pressing need for new national energy policies and some indications of constructive measures that might be taken are given below:

- Speed completion of facilities for supplying petroleum from Alaska.
- Stimulate maximum production of domestic oil and gas.
  - -- deregulate gas prices, thereby allowing prices to reduce demand and thus also provide capital for new exploration work.
  - -- increase the size and frequency of offshore lease sales.

CHART 9



- Nuclear energy development

  -- assist in overcoming siting and environmental obstacles.

- Coal

  -- permit strip mining, given adequate environment and land safeguards.

- Research

  -- encourage research on alternative energy sources: solar, nuclear fusion, coal gasification.

- Provide incentives to develop commercial coal gasification and liquefaction.

- Provide incentives to industry to substitute the use of coal for oil and gas in industrial and utility applications.

- Assist development of commercial stack gas scrubbing, thus permitting the use of high-sulfur oil and coal.

- Reduce product import requirements by facilitating through land use policies the siting and construction of new refineries and power plants.

- Encourage the construction of new tanker terminals.

The success of an action program such as that outlined above depends on the soundness of the measures proposed, on the adoption of a comprehensive set of policies, and on timely implementation. More than ever, the need is apparent for coordination of priorities at government level, so that conflicting social and economic pressures are resolved in the total context of community needs, and patchwork "solutions" avoided.

CHART 10